

CECW-CE

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**Engineering and Design
COMPREHENSIVE EVALUATION OF PROJECT DATUMS**

**Guidance for a Comprehensive Evaluation of Vertical Datums on Flood Control,
Shore Protection, Hurricane Protection, and Navigation Projects**

1. Purpose

This document provides guidance on the proper application of vertical datums used to reference protection elevations on flood control structures or excavated depths in navigation projects—hereinafter referred to as the Comprehensive Evaluation of Project Datums (CEPD) project. It describes specific procedural actions immediately required to evaluate the accuracy and adequacy of existing flood protection elevations or controlling navigation depths relative to federal datums established by the Department of Commerce and prescribed for government-wide use by the Federal Geographic Data Committee (FGDC). This guidance implements lessons learned from the Interagency Performance Evaluation Task Force (IPET) study conducted after Hurricane Katrina, as identified in Volume II (Geodetic Vertical and Water Level Datums) of the 1 June 2006 draft version of the Final IPET Report—see <https://ipet.wes.army.mil>. It is specifically intended to ensure that USACE project controlling elevations and datums are properly and accurately referenced to nationwide spatial reference systems used by other Corps Districts or Federal, state, and local agencies responsible for flood forecasting, inundation modeling, flood insurance rate maps, bathymetric mapping, and topographic mapping. It will be directly used in ERDC training sessions developed as a result of the IPET study. This document also implements and supersedes the interim guidance issued with a CECW-CE memorandum dated 4 December 2006, subject "Guidance for Establishing Primary Vertical Control on Flood Control Projects." This guidance also supports applicable portions of the National Levee Database (NLD) inventory project.

2. Applicability

This guidance applies to all USACE commands having responsibility for the project management, planning, engineering and design, operation, maintenance, and construction of civil works flood control, hurricane protection, shore protection, and navigation projects. This guidance is particularly applicable to hurricane and shore protection projects (HSPP) situated in coastal/tidal regions of the country, inland flood protection systems, and projects in areas with high rates of crustal subsidence or uplift.

3. Distribution

This publication is approved for public release; distribution is unlimited.

4. References

See Appendix A.

5. Scope

This guidance document distinguishes between inland and coastal projects. Appendix B contains guidance specific to upland or inland river flood control project elevations. Appendix C covers tide-based elevations on coastal navigation projects, shore protection projects, and hurricane protection structures. Appendix D provides guidance for documenting and web-based reporting to HQUSACE of each project's status. Appendix E references (but does not include) supplemental training material on geodesy, tidal models, and detailed examples of CEPD assessments for actual USACE projects. A copy of the Commanding General's 4 December 2006 directive memorandum is at Appendix F.

6. Discussion

A number of findings and lessons learned in the Hurricane Katrina IPET study (IPET 2006) revealed that hurricane protection structures were not designed and constructed relative to a vertical datum based on the most current hydrodynamic design model. In some cases, floodwall structures were mistakenly constructed relative to a terrestrial-based geodetic vertical datum instead of hydraulic/water-level referenced datums from which the structural protective elevations were designed. Often vertical datums specified for construction stakeout were based on older, superseded adjustments. Typically only a single benchmark was specified in the design documents, resulting in construction elevation uncertainties. Long-term land subsidence, seasonal tidal fluctuations, and sea level rise were not always fully compensated for in flood protection structure design or periodically monitored after construction. Aerial topographic mapping products were performed on a variety of datums and were inadequately ground-truthed. This caused difficulties in performing post-storm hydrodynamic surge modeling. In addition, navigation projects in tidal regions were often defined to a vertical reference datum that was not based on the latest tidal model for the region, or were defined relative to a datum that was inconsistent with recognized national or international maritime datums. The technical variations between geodetic, satellite-based (ellipsoidal), and water level datums, and their proper application on engineering and construction projects, were often misunderstood. These findings are outlined in detail in Volume II (*Geodetic Vertical and Water Level Datums*) of the referenced IPET Report. The following excerpt from the Report's Executive Summary synthesizes the need for this guidance:

A spatial and temporal variation was found to exist between the geodetic datums and the water level reference datums used to define elevations for regional hydrodynamic condition. Flood control structures in this region were authorized, designed, and numerically modeled relative to a water level reference datum (e.g., mean sea level).

However, these structures were constructed relative to a geodetic vertical datum that was incorrectly assumed as being equivalent to, or constantly offset from, a water level datum. These varied datums, coupled with redefinitions and periodic readjustments to account for the high subsidence and sea level variations in this region, significantly complicated the process of obtaining a basic reference elevation for hydrodynamic modeling, risk assessment, and design, construction, and maintenance of flood control and hurricane protection systems ...[need to] refine the relationships between the various datums that are numerically compatible with the varied hydraulic, hydrodynamic, geodetic, and flood inundation models such as those used by the Federal Emergency Management Agency (FEMA).

The critical need to firmly establish the relationships between hydraulic and geodetic datums is highlighted in Figure 1 below, in which an I-wall type floodwall was constructed 2 ft below grade. Also indicated is the requirement to firmly connect design and construction reference benchmarks to both hydraulic and geodetic datums, and verify the adequacy of those connections prior to construction.

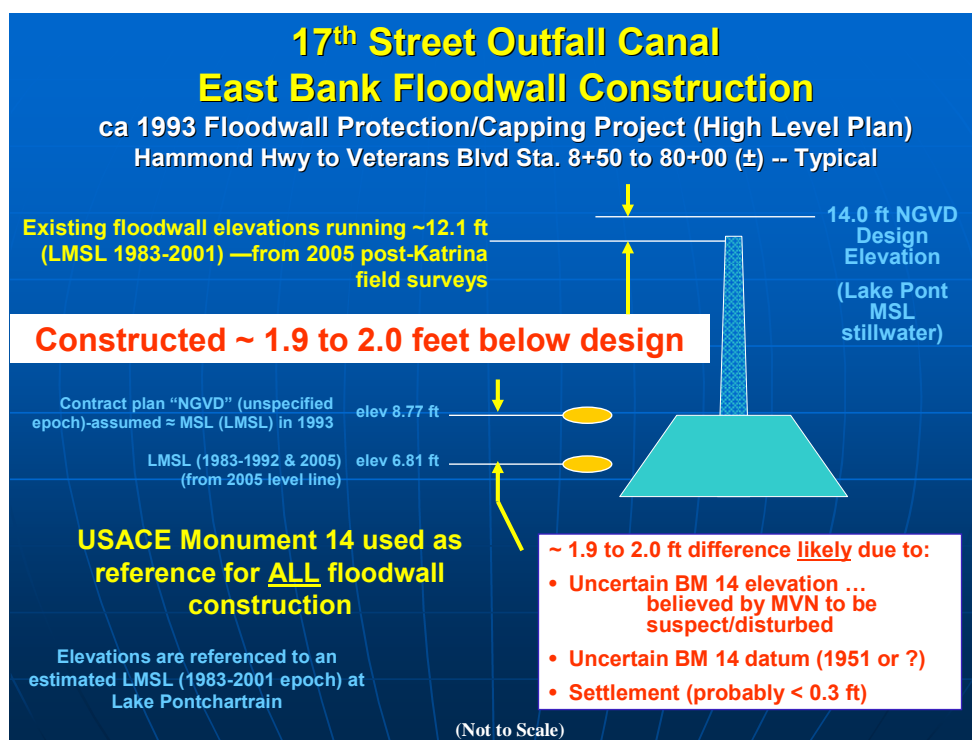


Figure 1. 17th Street Canal Floodwall Elevations—inconsistencies between geodetic and water level reference datums

The need for consistency on navigation project datums was also cited in the IPET report. The report cited a Water Resource Development Act (WRDA) 92 congressional action amending the Rivers and Harbors Appropriation Act of 1915. This amendment specifically required that navigation projects developed since the 1915 Act be referenced to a vertical mean lower low water datum (MLLW) defined by the Department of Commerce. The intent of WRDA 92 was to

supersede older MLW datums on the Atlantic and Gulf Coasts or locally defined navigation datums. Subsequent guidance issued in 1993 to implement the provisions of WRDA 92 has not been universally followed as some projects are still on older tidal datums or epochs.

SECTION 224: CHANNEL DEPTHS AND DIMENSIONS

Section 5 of the Act of March 4, 1915 (38 Stat. 1053; 33 U.S.C. 562),
is amended -- (as indicated)

Sec 5. That in the preparation of projects under this and subsequent river and harbor Acts and after the project becomes operational, unless otherwise expressed, the channel depths referred to shall be understood to signify the depth at mean lower low water as defined by the Department of Commerce for nautical charts and tidal predictions in tidal waters tributary to the Atlantic and Gulf coasts and at mean lower low water as defined by the Department of Commerce for nautical charts and tidal predictions in tidal waters tributary to the Pacific coast and the mean depth for a continuous period of fifteen days of the lowest water in the navigation season of any year in rivers and nontidal channels, and after the project becomes operational the channel dimensions specified shall be understood to admit of such increase at the entrances, bends, sidings, and turning places as may be necessary to allow of the free movement of boats.

(Rivers and Harbors Appropriation Act of 1915)

7. Implementation Actions

Since vertical reference datum uncertainties and deficiencies described above are known to exist in other USACE regions, an assessment is needed of the accuracy of flood/hurricane protection elevations on existing flood control, reservoir, impoundment, or like projects. Authorized coastal navigation projects likewise need to be evaluated to ensure that maintained or constructed depths are based on the latest hydrodynamic tidal model. In addition, Commands need to ensure all geospatial surveying and mapping is performed on datums that are consistent with national and Federal standards. The guidance in this document provides sufficient detail for making a preliminary assessment of critical projects and preparing a budget estimate for programming corrective actions. During this review, special attention must be made to assess the following critical issues associated with a project's vertical reference:

- Flood control structure crest elevations were designed relative to hydraulic or hydrodynamic models that were based on reliable water-level gauge data.
- Permanent benchmarks for river, pool, reservoir, and tidal reference gauges are placed at an adequate density and are accurately connected to the Department of Commerce National Spatial Reference Network (NSRS) used by Federal and local interests.
- Hurricane protection structure elevations have been designed and/or periodically corrected to the latest tidal epoch (currently 1983-2001) defined by the Department of Commerce (NOAA), and that these corrections additionally reflect any sea level, settlement, or subsidence/uplift changes.
- Coastal navigation project depths are defined relative to Mean Lower Low Water (MLLW) datum, and are being maintained to this datum and the latest tidal epoch as

defined by the Department of Commerce; as required by Section 224 of WRDA 1992 (33 U.S.C. 562).

- That navigation project depths are designed, maintained, and measured relative to hydrodynamic tidal models that are based on, or calibrated to, up-to-date water-level gauge data, and that field survey techniques are adequately compensating for short-term phase and slope variations in the water surface.

8. General Background on the Definition and Use of Vertical Datums

Vertical datums typically represent a terrestrial or earth-based surface to which geospatial coordinates (such as heights, elevations^{*}, or depths) are referenced. The vertical datum is the base foundation for nearly all civil and military design, engineering, and construction projects in USACE—especially those civil projects that interface with water. Elevations or depths may be referred to local or regional reference datums. These reference datums may deviate spatially over a region, due to a variety of reasons. They may also have temporal deviations due to land subsidence or uplift, sea level changes, crustal/plate motion, or periodic readjustments to their origin or to defined points on the reference surface.

In general, there are five types of vertical datums used to define USACE flood control and navigation projects.

- **Orthometric (Geodetic) Datums:** These datums are based on geopotential surfaces on some defined terrestrial origin—the geoid. Examples of orthometric datums include the National Geodetic Vertical Datum of 1929 (NGVD 29) and National Geodetic Vertical Datum of 1988 (NAVD 88). NAVD88 elevations are termed Helmert orthometric heights.
- **Hydraulic Datums:** These datums are found on inland river, lake, or reservoir systems, typically based on a low water pool or discharge reference point. Examples are the Mississippi River Low Water Reference Plane (LWRP 74 or LWRP 93) and the International Great Lakes Datum (IGLD 55 or IGLD 85). Hydraulic-based reference datums in inland waterways define stages of flood protection levees or floodwalls and navigation clearances. Dynamic height differences are often used in relating hydraulic datums. Dynamic heights, unlike orthometric heights, represent geopotential energy (hydraulic head) gradients in water surfaces (canals, rivers, lakes, reservoirs, hydropower plants, etc.) and thus have application to Corps hydraulic models.
- **Tidal Datums:** Tidal datums are used throughout all USACE coastal areas and are based on long-term water level averages of a phase of the tide. Mean Sea Level (MSL) datum is commonly used as a reference for hydrodynamic storm modeling. Depths of water in navigation projects in the United States are defined relative to Mean Lower Low Water (MLLW) datum. Tidal datums are essentially local datums and should not be extended more than a few hundred feet from the defining gauge without substantiating measurements or models.

* "heights" and "elevations" are assumed synonymous in this guidance, recognizing that a physical distinction exists between these two terms.

- Space-Based (Ellipsoidal) Datums: These are three-dimensional, geocentric, equipotential ellipsoidal datums used by the Global Positioning System (GPS)—i.e., GRS 80 and WGS 84. Ellipsoid heights of points in CONUS represent elevations relative to the GRS 80 reference system. The geoid height represents the elevation of the GRS 80 ellipsoid above or below the geoid.
- Local Datums: Local datums are based on an arbitrary, unknown, or archaic origin. Often construction datums are referenced to an arbitrary reference (e.g., 100.00 ft). Some datums with designated origins may be local at distant points—e.g., Cairo (IL) Datum projected south to the Gulf Coast. Most hydraulic-based river datums and navigation MLLW tidal datums are actually local datums when they are not properly modeled or kept updated.

The relationship within and between the above datums may or may not be easily defined. More often than not, the relationship is complex and requires extensive modeling to quantify—see Meyer 2006. These relationships are especially critical on coastal hurricane protection and navigation projects where accurate hydrodynamic tidal modeling is essential in relating water level elevations to a datum that varies spatially and is time varying due to subsidence or sea level changes—see IPET 2006. Thus, there is no consistent, non-varying, vertical datum framework for most coastal areas—periodic survey updates and continuous monitoring are required for these projects.

Establishing a solid relationship between hydraulic/tidal datums and geodetic datums is critical in relating measurements of wave heights and water level elevations, high-resolution hydrodynamic conditions, water elevations of hydrostatic forces and loadings at levees and floodwalls, elevations of pump station inverts, and related elevations of flood inundation models deriving drainage volumes or first-floor elevations in residential areas. This is best illustrated by the following:

... the land-water interface depends on how water levels change in both space and time. To combine or compare coastal elevations (heights and depths) from diverse sources, they must be referenced to the same vertical datum as a common framework. Using inconsistent datums can cause artificial discontinuities that become acutely problematic when producing maps at the accuracy that is critically needed by Federal, state, and local authorities to make informed decisions (Parker 2003).

The current use of GPS satellite-based ellipsoidal reference systems does provide a mechanism for establishing an external reference framework from which vertical datums can be related spatially and temporally. Various initiatives are underway by National Oceanic and Atmospheric Administration (NOAA), Federal Emergency Management Agency (FEMA), and other agencies to refine the models of some of the various vertical datums listed above—resulting in a consistent National Spatial Reference System that models and/or provides transformations between the orthometric, tidal, and ellipsoidal datums. Paramount in these efforts is the NOAA "National VDatum" project which is designed to provide accurately modeled transformations between orthometric and tidal datums.

Detailed technical background on geodetic reference systems is covered in the guidance documents listed below. Those charged with performing an assessment of project vertical datums shall acquire a detailed familiarity with the guidance in these reference documents.

IPET 2006, "Performance Evaluation of the New Orleans and Southeast Louisiana Hurricane Protection System," Draft Final Report of the Interagency Performance Evaluation Task Force, US Army Corps of Engineers, 1 June 2006, Volume II-- "Geodetic Vertical and Water Level Datums," (entire document)

EM 1110-1-1003, "NAVSTAR GPS Surveying," Chapter 4, "GPS Reference Systems."

EM 1110-2-1005, "Control and Topographic Surveying"
Chapter 5: Geodetic Reference Datums and Local Coordinate Systems
Section III (Vertical Reference Systems)
Appendix B: Requirements and Procedures for Referencing Coastal Navigation Projects to Mean Lower Low Water (MLLW) Datum
Appendix C: Development and Implementation of NAVD 88

Meyer 2006, "What Does Height Really Mean," Meyer, Roman, Zilkoski
Part I: Introduction
Part II: Physics and Gravity
Part III: Height Systems
Part IV: GPS Orthometric Heighting

NOS, 2001, "Tidal Datums and Their Applications," NOAA Special Publication NOS CO-OPS 1, NOAA/NOS, Center for Operational Oceanographic Products and Services, Silver Spring MD, February 2001.

EM 1110-2-1003, "Hydrographic Surveying," Chapter 5, "Project Control, Coordinate Systems, and Datums," Section 5-4 through 5-24.

EM 1110-2-1100, "Coastal Engineering Manual—Coastal Hydrodynamics (Part II)," Chapter 5, "Water Levels and Long Waves," Section II-5-4 (Water Surface Elevation Datums).

EM 1110-2-1100, "Coastal Engineering Manual—Coastal Hydrodynamics (Part II)," Chapter 6, "Hydrodynamics of Tidal Inlets."

9. National Spatial Reference System (NSRS)

The NSRS represents an independent framework system for long-term monitoring of the stability of project grades and flood protection elevations. This reference system has been adopted by most Federal agencies, including FEMA, USGS, EPA, and most state transportation departments (DOT). The NSRS is a national reference framework that specifies latitude, longitude, height

(elevation), scale, gravity, and orientation throughout CONUS. Accordingly, USACE must ensure flood control projects and navigation projects are referenced to this NSRS system. This insures consistency in reporting elevations or grades between agencies and represents one of the primary purposes of this CEPD effort. In addition, incorporating Corps project control into the NSRS minimizes the need for maintaining independent databases at each District. It also ensures that Corps project control will be automatically updated when future updates to the NSRS are made.*

The NSRS is also a component of the National Spatial Data Infrastructure (NSDI) - [<http://www.fgdc.gov/nsdi/nsdi.html>] which contains all geodetic control contained in the National Geodetic Survey (NGS) database. This includes: A, B, First, Second and Third-Order horizontal and vertical control, geoid models, precise GPS orbits, Continuously Operating Reference Stations (CORS), and the National Shoreline as observed by NGS as well as data submitted by other Federal, State, and local agencies, academic institutions, and the private sector.

Permanent benchmarks or primary control points on USACE projects that are firmly connected to the NSRS shall be submitted to NGS for inclusion in the published NSRS. Details on this process are covered in Appendix B.

10. Minimum Criteria for Evaluating the Adequacy of Geodetic and Water Level Datums on Flood Control and Navigation Projects

A project-by-project assessment of the adequacy of the vertical reference network should be evaluated based on the general criteria described below. Projects that do not conform to these minimum standards are considered deficient and require remedial action following the guidance in Appendix B or C. The assessment items below should be addressed in the evaluation report for each project (Appendix D), as applicable. A more comprehensive checklist of CEPD assessment items is listed in Appendix D, including direct connection links with a web-based report to HQUSACE on critical items.

(1) Verify the existence of a permanent water level gauge network that adequately defines the spatially varying hydraulic or tidal datum in the project region. Existing or historical gauges should be established at a sufficient density such that the spatially varying hydraulic datum anomalies are (or were) modeled to an accuracy consistent with project requirements. USACE, NOAA, National Weather Service (NWS), Environmental Protection Agency (EPA), United States Geological Survey (USGS), State Department of Transportation (DOT), and other agency gauges may be utilized for this network. (Reference EM 1110-2-1100 (*Coastal Engineering Manual*), Section II-5 (Water Levels and Long Waves) and Section II-6 (Hydrodynamics of Tidal Inlets)).

(2) Verify that the original and/or periodic maintenance design documents (DM, GDM, P&S, etc.) indicate that constructed project grades (or excavated navigation depths) are based on direct hydraulic or tidal observations, and that the relationship between the hydraulic/tidal datum

* Note that the NSRS, and NAVD88 control therein, will be updated by NGS in the near future

and the geodetic datum used for construction (e.g., NGVD 29 or NAVD 88) was firmly established.

(3) Verify that coastal navigation projects were converted from Mean Low Water (MLW), Mean Low Gulf (MLG), or other local tidal datums, to MLLW as a result of the requirements in WRDA 92 (33 U.S.C 562) that superseded older tidal datums and epochs; and that these revisions are based on the latest NOAA tidal model and not on approximated or estimated translations. Projects still defined relative to undefined or superseded datums—e.g., "Mean Sea Level--MSL," "Mean Low Gulf," "Mean Tide Level," "Sea Level Datum--SLD," "NGVD," "MSL 1912," or "NGVD 29"—are considered deficient and in need of updating. There may be limited exceptions to this in OCONUS locales.

(4) Verify that reported elevations of coastal protection structures and maintained depths of navigation projects fully account for geological and climatological factors that may impact their integrity—e.g., sea level change, eustatic rise, crustal subsidence, tectonic uplift or downwarp, seismic subsidence, seasonal sea level biases, etc. See EM 1110-2-1100 (*Coastal Engineering Manual*), Section II-5-4-f (Tidal Datums).

(5) Verify USACE operated gauge networks are periodically inspected at adequate intervals to verify the gauge reference setting and other criteria. Gauge inspection and referencing procedures should be documented in a standards manual, or, at minimum, conform to gauge inspection criteria used by the Department of Commerce (NOAA). This also applies to gauges from other agencies that are used in USACE models.

(6) Verify USACE operated water level gauges are referenced to, at minimum, three (3) permanent benchmarks. Verify that each scheduled inspection visit connects the gauge reference mark to stable benchmarks by 3rd Order differential levels, and that these inspection records are properly archived.

(7) Verify that, at minimum, one benchmark at each flood control structure site, shore protection site, water level gauge, etc. is geodetically connected to the NAVD88 orthometric datum on the NSRS network maintained by the National Geodetic Survey (NGS), and that this benchmark(s) is published in the NSRS. In areas where subsidence or crustal uplift is known to exist, this connection must have been made periodically in order to monitor potential loss of flood protection or navigation grade. This may require establishment of vertical time-dependent networks—see IPET 2006.

(8) Verify that current project documents (or equivalent CADD databases) used in design or construction plans accurately describe the source and datum of any elevations or depths. Verify master project drawings have sufficient feature codes or metadata that notes the reference datum, source, location, adjustment epoch, and dates of tidal or hydraulic observations, etc.

(9) Verify all USACE operated and maintained projects have, at minimum, three up-to-date vertical control benchmarks identified in the most recent contract plans and specifications from which to stake out construction. Confirm these controlling benchmarks have dual elevations on the latest adjustments and/or epochs: (1) hydraulic/tidal and (2) NAVD88 (NSRS).

(10) Verify permanent benchmarks on navigation projects are at a sufficient density (i.e., spacing) needed to adequately model the water surface vertical datum for project maintenance, including controlling dredging grades and related measurement & payment/clearance survey; and that these benchmarks are directly referenced to NOAA tidal benchmarks.

(11) Verify permanent benchmarks shown on the most recent contract plans and specifications contain complete metadata descriptions—date, adjustment, epoch, monument description, etc.

(12) Verify hydraulic-based inland river reference datums (and reference benchmarks therefore) are firmly connected to river gauges and the NSRS. This includes various inland datums such as Low Water Reference Planes (e.g., LWRP74 and LWRP93), Minimum Regulated Pool, Flat Pool Level, Full Pool Level (for overhead clearance), Mean Sea Level 1912, International Great Lakes Datum (1985), and various other inland reference planes.

11. Corrective Actions Required for Projects Not Meeting Minimum Standards

Projects deemed to be deficient in any of the criteria outlined above will require corrective action. The amount of time and expense will vary considerably, depending on the geographical size of the project, risk assessments, the density and reliability of existing water level gauges, USACE or NOAA modeling support and capability, and various other factors. Coastal projects requiring updated tidal models may require the most effort. Updating river, pool, or reservoir gauge elevations will require minimal time and expense. The CEPD assessment report for each project should provide an estimate of the recommended corrective action. This estimate should be of sufficient detail to allow programming the action into the next budget cycle for the project. The guidance listed below is intended to support making this budget estimate for programming purposes.

a. Coastal Project Reference Datums. Projects in tidal areas that were not adequately updated to a current MLLW (or MSL) reference datum, or have outdated or unknown origin tidal modeling regimes (phase and range), or are on superseded epochs, will require initiating an effort to reliably update a model for the project. This may require setting one or more short-term tidal gauges to perform simultaneous comparison datum translations between an existing National Water Level Observation Network (NWLON) station and/or developing a tidal model utilizing the hydrodynamic modeling techniques which can be applied to develop the MLLW datum relationship over a project reach. Minimizing tidal phase errors may require mandated utilization of GPS (RTK) elevation measurement in lieu of extrapolated gauge elevations. Details are covered in Appendix C.

b. Water Level Gauge Upgrades. USACE-operated water level gauges that are used to reference elevations of flood control projects or tidal parameters on navigation projects must be rigorously maintained and documented. A primary benchmark for each gauge shall be surveyed and placed into the NSRS and continuously maintained in that file. District procedures should meet or exceed the standards set forth by the Department of Commerce (Center for Operational Oceanographic Products and Services—CO-OPS). USACE river gauges with insufficient

reference benchmarks (i.e., minimum of three) must be upgraded. This can be accomplished with either hired-labor or contract forces. An assessment should evaluate existing District gauge inspection procedures against the following CO-OPS specifications:

Specifications and Deliverables for Installation, Operation, and Removal of Water Level Stations. NOAA Special Publication NOS CO-OPS, NOAA/NOS, Center for Operational Oceanographic Products and Services, Silver Spring MD, February 2003.

User's Guide for the Installation of Bench Marks and Leveling Requirements for Water Levels. National Ocean Service, Rockville, MD, October 1987.

Standing Project Instructions and Requirements for the Coastal Water Level Stations. Center for Operational Oceanographic Products and Services, Silver Spring MD, October 2005.

The above specifications can be obtained at <http://tidesandcurrents.noaa.gov/>

c. Geodetic Control Survey Connections to the NSRS. River/tidal gauge primary benchmarks and primary reference benchmarks on dams, pools, lakes, reservoirs, or like projects requiring ties to the NSRS (i.e., NAVD88) can often be economically accomplished using GPS height transfer methods. Appendix B of these guidelines describes procedures for transferring orthometric elevations between points. Conventional differential leveling may be a more economical option, especially over short distances. Permanent benchmarks or primary project control points established or reestablished should be submitted to NGS for inclusion in the NSRS. Refer to Appendix B for details.

d. Projects on Non-Standard or Undefined Tidal Datums. Projects on antiquated or non-standard tidal datums must be converted to the MLLW datum established by NOAA used for coastal navigation and maritime charting in CONUS waters. This includes those projects that are still referenced to datums such as Mean Low Water (MLW), Mean Gulf Level (MGL), Mean Low Gulf (MLG), Gulf Coast Low Water Datum, Old Cairo Datum 1871, Delta Survey Datum 1858, New Cairo Datum 1910, Memphis Datum 1858 & 1880, Mean Tide Level, etc. Reference WRDA 92.

e. Mean Sea Level or NGVD Datums. Projects or benchmarks defined generically to "mean sea level" or "NGVD" without any definitive source data (metadata) probably have no firmly established relationship and need to be resurveyed. "NGVD 29" was once known a "Sea Level Datum of 1929." However, neither NGVD 29 nor the current NAVD 88 datums are related to "mean sea level." Resurveying entails establishing a hydraulic and NSRS geodetic reference, as applicable.

f. Permanent Benchmark Control Requirements for Dredging and Flood Control Structure Construction. Projects without a sufficient density (minimum number and spacing) of vertical control must be programmed for additional survey work—either by USACE or local sponsors, depending on the O&M status of the project. Additional permanent benchmarks (i.e., primary project control marks) should be added as necessary to control the project for conventional

surveying methods, or preferably at a sparser density needed to accommodate GPS real-time kinematic construction control methods. These permanent benchmarks must be firmly connected to applicable hydraulic gauges and regional NSRS datums as described above and, where required (see Appendix B) should be submitted to NGS for inclusion into the NSRS.

g. Local Mean Sea Level Datum. For storm surge modeling, flood inundation models, and similar purposes, "Local Mean Sea Level" is distinguished from "Mean Sea Level" computed at a fixed water level gauge. As stated previously, sea level reference datums vary spatially depending on the tidal regime in the area. Therefore, "Local Mean Sea level" elevations should be assigned to monuments based on hydrodynamic models of the tidal regime in an area.

h. Projects Subject to High Subsidence Rates. Projects located in high subsidence areas may require special attention. This also applies to areas on the Northwest coast (e.g., Alaska) that may be subject to crustal uplift. Vertical elevations of reference benchmarks, water level gauges, and protection structures must be continuously monitored for movement and loss of protection. This monitoring can be accomplished using static GPS survey methods or conventional differential leveling. In high subsidence areas (portions of California, Texas, and Louisiana) independent local vertical control networks have been established for these purposes. These vertical networks are periodically resurveyed at intervals dependent on subsidence rates. In the New Orleans, LA area, control benchmarks on these monitoring networks are time-stamped to signify reobservation/readjustment epochs—e.g., BM XYZ (2004.65). Refer to IPET 2006 for additional details. Additional technical guidance for monitoring subsidence or uplift can be obtained from the Topographic Engineering Center (ERDC/TEC) and the NOAA National Geodetic Survey (NGS).

12. Project Review, Certification, and Reporting

Designated coordinators responsible for reviewing and certifying the adequacy and accuracy of vertical control on a given project must have a solid background in surveying, mapping, and geodesy, and especially must have knowledge of the latest GPS technology used for extending vertical control and real-time construction layout. These project reviews are to be conducted and submitted to HQUSACE using a web-based tool developed and designed for this effort. Once the review is completed, the designated coordinator is to print out the report and have it signed by the District Commander. This signed copy is to be sent to HQUSACE. The submitted report to HQUSACE should contain clear findings and delineate any remedial surveying actions that may be required for each project—including a budget cost and time estimate to rectify any identified vertical reference deficiencies. Additional details are contained in Appendix D, "Documentation and Reporting for Comprehensive Evaluation of Project Datums."

13. Programming Evaluation and Implementation Actions

In general, Districts will fund the CEPD review of flood control and hurricane protection projects operated and maintained by non-federal sponsors within the Inspection of Completed Works (ICW) account. CEPD review of Corps-maintained projects, including navigation projects, will be funded from existing O&M accounts associated with those projects.

Mechanisms for funding the initial CEPD assessment and programming subsequent corrective actions are detailed in Appendix D.

14. Technical Assistance and Training

This technical guidance was developed by the Topography, Imagery, & Geospatial Research Division of the U.S. Army Engineer Research and Development Center—Topographic Engineering Center (TEC). That office is also responsible for developing a joint USACE-NOAA training course on vertical reference datums that is intended to supplement evaluation actions in this guidance. Designated coordinators for this assessment action should contact TEC for technical assistance and interpretations regarding this guidance. The point of contact at TEC is Mr. James Garster (CEERD-TR-A), e-mail James.K.Garster@usace.army.mil. An alternate technical point of contact is Mr. David Robar (CESAJ-EN-D), e-mail David.J.Robar@saj02.usace.army.mil. An Additional technical point of contact for hydrodynamic tidal modeling at ERDC Coastal Hydraulics Laboratory is Kevin Knuuti (CEERD-HN-CE), email Kevin.Knuuti@usace.army.mil. Technical points of contact at NOAA/NOS include:

NGS: Mr. Ronnie Taylor Ronnie.Taylor@noaa.gov

OCS/CSDL/VDatum Group: Ms. Maureen Kenny Maureen.Kenny@noaa.gov

CO-OPS: Mr. Jerry Hovis Gerald.Hovis@noaa.gov

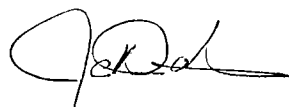
15. Periodic Reassessments of Controlling Reference Elevations

Subsequent periodic reevaluations of project reference elevations and related datums covered in this document will likely be included as an integral component in the various civil works inspection programs of completed projects—see IPET 2006. The frequency that these reevaluations will be needed is a function of estimated magnitude of geophysical changes that could impact flood protection or navigation grades. Project elevations and dredging grades that are referenced to tidal datums will have to be periodically coordinated with and/or reviewed by NOAA to ensure the latest tidal hydraulic effects are incorporated and that the project is reliably connected with the NSRS. In all cases, a complete reevaluation of the vertical datum should be conducted at each scheduled periodic inspection—e.g., NTE 5 years. Shallow-draft navigation projects may have different criteria. Any uncertainties in protection levels that are identified during the inspection will also need to be incorporated into any applicable risk/reliability models developed for the project—see EM 1110-2-1619 (*Risk Based Analysis for Flood Damage Reduction Studies*). Details on these periodic reevaluations will be provided in subsequent guidance.

16. Proponency and Waivers

The HQUSACE proponent for this interim guidance is the Engineering and Construction Division, Directorate of Civil Works. Waivers to this guidance should be forwarded through MSC to HQUSACE (ATTN: CECW-CE).

FOR THE COMMANDER



JAMES C. DALTON, P.E.
Chief, Engineering and Construction
Directorate of Civil Works

7 Appendices

Appendix A – Reference Documents

Appendix B – Guidance, Standards, and Specifications for Referencing Levee Systems and Related Flood Control Projects to the National Spatial Reference System (NSRS) and to the North American Vertical Datum of 1988 (NAVD88)

Appendix C – Guidance, Standards, and Specifications for Referencing Coastal Navigation Projects, Hurricane Protection Projects, and Shore Protection Systems to National Water Level Observation Network Datums

Appendix D – Documentation and Reporting for Comprehensive Evaluation of Project Datums

Appendix E – List of Supplemental Training Material to Accompany this Guidance Document

Appendix F – CEPD Directive Memorandum